TB MED 200

WAR DEPARTMENT TECHNICAL BULLETIN

SPRAYING OF DDT FROM AIRCRAFT

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TB MED 200, Spraying of DDT from Aircraft, is published for the information and guidance of all concerned.

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CONTENTS

Section I

INTRODUCTION

1. GENERAL. *a.* The purposes of this bulletin are to discuss the advantages and limitations of dissemination of DDT (dichloro-diphenyl-trichloroethane) from aircraft and to describe recommended equipment and procedures. The equipment is the simplest which has been shown to meet the military objective of airplane spraying. For the most part, it can be made in the field, is temporary, and will be replaced as soon as possible by standard equipment which will be available on requisition.

b. The attention of commanding officers of all grades is invited especially to section II, which discusses certain principles in regard to aerial spraying; of Medical Corps and Sanitary Corps officers to both sections II and III; and of pilots, maintenance crews, and others immediately concerned to section III, which describes technical aspects of aerial dispersal of DDT sprays.

Section II

PRINCIPLES

2. OBJECTIVE OF AIRPLANE SPRAYING. *a.* The objective of spraying DDT from aircraft is the conservation of effective strength by reducing the numbers of casualties from insect-borne diseases such as malaria, dengue, and dysentery, by the destruction of the vectors of these diseases. A single application of DDT spray, if well applied, may accomplish such a reduction in the numbers of mosquitoes and flies that for a limited period there will not be enough remaining alive to spread a significant amount of disease. A subsidiary objective of airplane spraying may be the reduction of certain insect pests which interfere with efficient operations. The limitations of this technique are discussed in paragraph 5.

b. The objectives of airplane spraying may be reached in two ways, each of which requires technical consultation:

(1) *By killing adult mosquitoes and flies.* This is the most direct method of control, since the cycle of disease transmission is broken immediately. The procedures recommended should effect a 90 percent or greater kill, but they should not be considered as useless, if this is not accomplished. The criteria of effectiveness are a reduction in the vector population and a low incidence of disease transmitted by these insects.

(2) *By killing mosquito larvae.* This method of control is less direct and may require several weeks before its effects become apparent. Aerial spray may be the only or the most appropriate method of destroying larvae in extensive marshes or inaccessible breeding areas. This procedure is especially applicable about fixed installations at the beginning of the mosquito season, when early spraying of DDT will prevent subsequent rapid increase in the mosquito population.

3. INDICATIONS FOR AIRPLANE SPRAYING. The dispersal of DDT by aircraft for mosquito and fly control should be used where it offers sufficient economy of manpower to justify application, where there is insufficient time to establish effective ground control, or where circumstances prevent access to mosquito breeding sites. Aircraft dispersal of DDT sprays may be applicable both in forward areas and in rear areas.

a. Forward areas. The use of aircraft to disperse DDT in battle zones, such as during the establishment of beachheads and at perimeter defense zones, constitutes an effective weapon for the control of insects at a critical period, when the possibility of infection of troops with insect-borne diseases usually is high. Various

techniques and equipment, including Chemical Warfare Service smoke tanks carried by combat aircraft, were used in battle operations during World War II. Further development of equipment and of methods of application is required before general recommendations can be made for spraying in battle zones. Consequently, the technique and equipment for aerial dispersal of DDT in forward areas using combat aircraft are not presented in this bulletin.

b. Rear areas. Rear areas are defined here as those installations over which unarmed aircraft may be flown at low levels.

(1) *Airplane spraying of rear areas.* Occasionally this is the method of choice for mosquito control. Usually it is complementary to the usual methods of ground control. Under certain circumstances it may be the only feasible method. It is generally indicated in newly occupied territory until the area is controlled by ground methods, and in the face of an epidemic of a disease transmitted by mosquitoes, flies, or sandflies. In temporary camps, repeated aerial spraying may be the most practicable and economical method of insect control.

(2) *Types of aircraft.* The following types of aircraft are recommended and are considered in detail below: the B-25, C-47, L-5, and L-4. The PT-17, the primary trainer which is available at many stations in the zone of interior, also may be used for the dispersal of insecticides. When equipped with the breaker bar equipment, this plane provides as efficient a unit as either the L-5 or L-4 with the same equipment.

(3) *Target.* The area to be sprayed should be determined by previous entomological studies and aerial survey. It may be possible in most terrain to increase the accuracy of spraying by marking lines of flight with Chemical Warfare Service HC-smoke bombs. Any type of pyrotechnic smoke marker must be used with great care, especially during the dry season, in order to avoid starting grass or forest fires. Radio communication between air and ground crews should be maintained during the spraying operations to insure proper area coverage and maintenance of the flight pattern.

(4) *Time of spraying.* The area should be sprayed as soon as possible after occupation, since DDT is not significantly effective until 2 to 4 hours after application, and reaches a maximum after 24 hours. Spraying at dawn or predusk gives the best results, since meteorologic conditions generally are most favorable at that time. (See also par. 9.)

4. DURATION OF EFFECT. *a.* Great reduction in numbers of adult mosquitoes may be obtained for a week or longer following a single application of DDT spray. When a large area is treated, effective control of the transmission of mosquito-borne diseases persists for about 2 to 3 weeks even though adult mosquitoes may appear in increasing numbers within approximately 1 week. The greatest number of such mosquitoes will have hatched from pupae which have not been affected by DDT and at first may be regarded as pests rather than as disease vectors, because an additional minimum period of 8 to 12 days must elapse before these mosquitoes can become infective. This situation does not apply after wind storms, which are likely to drive infective mosquitoes long distances from a disease focus into a previously sprayed area. Infective mosquitoes also may infiltrate normally from the margins of a sprayed area. Accurate information is lacking regarding time factors and the extent of such migration. The duration of effectiveness of a single application of DDT spray is variable and probably depends upon a number of factors, such as flight habits of the mosquito species, density of vegetation or jungle cover, dosage of DDT, particle size of spray, and meteorologic factors, such as wind and rainfall.

b. Effective control of adult flies by a single spraying may be 3 to 7 days. Longer control of fly-borne diseases is not obtained because immediately after the adult fly emerges from the larval stages it is capable of transmitting disease. Airplane spraying of DDT does not kill fly larvae.

c. Prolonged residual effect against mosquitoes and flies is not obtained by aerial spraying with present methods.

5. LIMITATIONS. *a.* Aerial spraying of DDT usually is a complement to other methods of mosquito and fly control, but rarely a substitute for it. No relaxation of individual and

unit methods of insect control and disease prevention is permissible.

b. The application of aerial spraying in certain situations is limited by the flight characteristics of the type of aircraft selected for use. These limitations should be determined by consultation with appropriate flight personnel. (See par. 9.)

c. Type of terrain and size of the area to be treated are determining factors in selection of the appropriate aircraft, of the dosage of DDT, and in results to be expected. These factors are briefly discussed in paragraph 8. At present it is not possible to classify types of terrain and to correlate them with adequate dosage of DDT except in a rather general way.

d. In populated regions consideration must be given to possible harmful effects of large-scale application of DDT on beneficial insects, agriculture, fish, and other wild life. DDT kills beneficial insects as well as those which are harmful. The effect of DDT on insect predators of mosquito larvae varies greatly with different species, but heavy dosage of DDT is lethal to nearly all aquatic insects and to many of the fish which feed on larvae. In combat areas the urgency of the military situation may require that such considerations be ignored. To prevent indiscriminate use of aerial dispersion of DDT in the United States, such projects must be approved by the appropriate higher authority in accordance with current War Department directives.

Section III

TECHNICAL ASPECTS

6. SOLUTIONS. *a. Formula.* It is recommended that, in general, 5 percent solution of DDT (weight/volume) in No. 2 fuel oil be employed for aerial spraying. When available, a 20 percent DDT concentrate may be made by diluting 40 percent solutions in an appropriate auxiliary solvent to 20 percent solution. The advantage of such a concentrated solution is mainly in the ability to cover a wider area with a single flight. This assumes considerable importance when small planes are employed. Standardized insecticide preparations available are listed in current War Department circulars.

b. Preparation of solution. (1) *For large volumes.* (*a*) Add 170 pounds of larvicide, DDT powder, dissolving (QM stock No. 51-L-120) to about 250 gallons of oil in a Chemical Warfare Service apparatus, decontaminating, power-driven, type M3A1 or M-4. Fill with oil to the 400-gallon mark. About 385 to 390 gallons of oil are required.

(*b*) Approximately 30 minutes of mixing are necessary to dissolve the DDT completely.

(*c*) 400 gallons of solution may be transferred to the B-25 or C-47 in 20 minutes, including the time required for placing the hose. Two decontamination trucks are required to keep the C-47 or B-25 operating efficiently during spraying missions.

(2) *For small volumes.* Remove 10 gallons of oil from a 55-gallon drum. Mix 5 gallons of this with 25 pounds of DDT powder and pour the mixture back into the 55-gallon drum. Rinse out the mixing container with the oil which remains, filling the 55-gallon drum. Roll the drum or stir the contents frequently, preferably in the heat of the sun, and allow 24 hours for complete solution. The transfer of solution may be accomplished using a pump and refilling unit, hand-operated (stock No. 7600-420300).

c. Auxiliary solvents. Auxiliary solvents such as gasoline or benzene, are not recommended on account of fire hazard, and carbon tetrachloride on account of its toxicity.

7. RATE OF APPLICATION. *a.* 0.6 pound of DDT per acre is the recommended rate of application from large pay-load aircraft. This rate will give good results when applied properly over jungle, native villages, and lake-jungle (beachheads).

b. 0.3 pound DDT per acre is the rate recommended for small planes, namely, the L-4, L-5, and PT-17. The slower speed of the light aircraft and ready maneuverability and lower optimum altitude flown permit more exact ap-

plication of solution. This rate also may be effective in open water areas, rice fields, or over terrain with scanty vegetation, when applied from larger aircraft. The decision rests with the malariologist and/or the entomologist.

varied by increasing or decreasing (covering) the holes in the pipe. The new rate may be calculated on the basis of the rate for a single hole.

(2) By changing the flight interval.

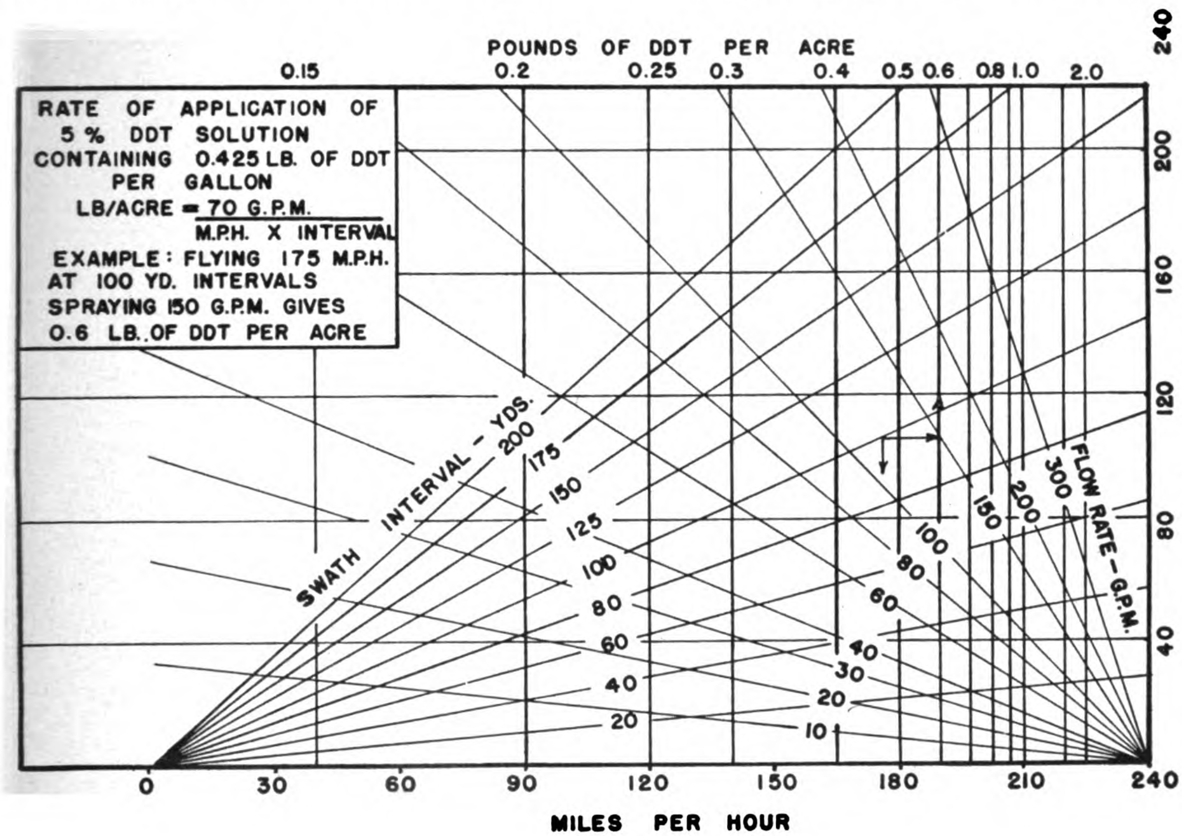


Figure 1.

c. Rate of application (pounds per acre) =

$$\frac{70 \times \text{discharge rate (gallons per minute)}}{\text{miles per hour} \times \text{swath width (yards)}}$$

(See fig. 1.)

d. The rate of application may be varied as follows:

(1) By changing the rate of discharge through the release mechanisms. Prior to use, the flow rate of any release valve manufactured locally should be calibrated.

(*a*) Various sized discharge pipes calibrated for different rates of flow are used as interchangeable equipment. These are covered with an outer fairing to produce the desired air turbulence.

(*b*) The rate of the L–4 and L–5, when equipped with breaker bar equipment, can be

e. Tables I and II show various characteristics of aerial spraying which will permit application of the recommended amount of DDT.

8. AREA COVERED. *a.* The B–25 carrying 550 gallons of 5 percent DDT solution will cover a maximum of 390 acres on one flight at a rate of 0.6 pound per acre.

b. The C–47 carrying 625 gallons will cover a maximum of 435 acres at 0.6 pound per acre.

c. The L–5 carrying 42 gallons will cover a maximum of 60 acres at 0.3 pound per acre.

d. The L–4 carrying 25 gallons will cover a maximum of 33 acres at 0.3 pound per acre.

e. The use of more concentrated solutions, 10 to 20 percent DDT, increases from two to fourfold the area to be covered in a single flight. Safe auxiliary solvents are becoming available for general military uses, and further studies of their use are being made.

TABLE I.—*Table of coverage possible by various aircraft under recommended flight conditions, rates of application, and discharge rate*

Type of aircraft	Capacity of aircraft		Flight recommendations			Discharge rate	Rate of application	Coverage in one flight of aircraft		
	Gallons 5 percent solution	Pounds DDT	Altitude (ft.)	I. A. S. (mph.)	Swath interval (yds.)	Gallons per minute	Pounds per acre	Yards	Miles	Acres covered
B-25	550	235	150	200	100	170	0. 60	19, 000	10. 8	390
	550	235	150	200	200	170	. 30	19, 000	10. 8	780
C-47	625	260	150	170	100	145	. 60	21, 600	12. 2	434
	625	260	150	170	150	220	. 60	14, 240	8. 1	434
	625	260	150	170	200	290	. 60	10, 380	6. 1	434
	625	260	150	170	100	*72	. 30	43, 500	24. 6	868
	625	260	150	170	150	*110	. 30	28, 500	16. 1	868
	625	260	150	170	200	*145	. 30	21, 600	12. 2	868
L-5	42	18	40	90	27	10	. 30	11, 100	6. 3	60
	42	18	40	90	14	10	. 60	11, 100	6. 3	30
L-4	25	10	40	70	27	7. 7	. 30	6, 600	3. 7	33
	25	10	40	70	14	7. 7	. 60	6, 600	3. 7	17
PT-17	60	25. 5	40	90	27	10	. 30	15, 900	9. 0	86

*Using various size outlet pipes.

TABLE II.—*Table of average discharge rates for 5 percent DDT in No. 2 fuel oil required to give recommended rate of application under optimum flight conditions*

Type of aircraft	Capacity of aircraft		Flight recommendations			Recommended rate of application per acre		Discharge rate of 5 percent DDT in No. 2 fuel oil (gal per min)[3]
	Gallons 5 percent DDT solution[1]	Pounds DDT	Altitude (ft)	I. A. S. (mph)[2]	Swath interval (yds)	Pounds DDT	Quarts DDT spray	
B-25	550	235	150	200	100	0. 6	5. 6	170
	550	235	150	200	200	. 3	2. 8	170
C-47	625	260	150	170	100	. 6	5. 6	145
	625	260	150	170	150	. 6	5. 6	220
	625	260	150	170	200	. 6	5. 6	290
	625	260	150	170	100	. 3	2. 8	72
	625	260	150	170	150	. 3	2. 8	110
	625	260	150	170	200	. 3	2. 8	145
L-5	42	18	40	90	27	. 3	2. 8	10
	42	18	40	90	14	. 6	5. 6	10
L-4	25	10	40	70	27	. 3	2. 8	7. 7
	25	10	40	70	14	. 6	5. 6	7. 7

[1] 0.425 pounds of DDT per gallon of solution.
[2] In the calculations, ground speed is assumed to be the same as indicated air speed (I. A. S.). This will be nearly true at low wind speeds in cross-wind flights.
[3] Variations in discharge rate for the C-47 airplane presuppose the use of various size outlet pipes.

9. FLIGHT CONDITIONS. The following flight conditions are optimum for airplane spraying. It is recommended that they be adhered to when feasible.

a. Altitude of release. (1) *B–25 and C–47: 150 feet.* Over jungle or dense timber areas it may be necessary to fly as low as 50 feet above treetops for better penetration of spray.

(2) *L–4 and L–5: 40 feet.* It will be necessary to fly at a higher altitude over irregular terrain. It is not recommended to spray from altitudes above 100 feet.

b. Indicated air speed.

B–25—200 miles per hour.
C–47—170 miles per hour.
L–5—90 to 100 miles per hour.
L–4—70 to 80 miles per hour.

c. Wind velocity. Three to ten miles per hour measured on the ground.

d. Line of flight. Within 22° of right angles to the wind direction.

e. Distance between lines of flight. B–25 or C–47—100 yards; L–4 and L–5—27 yards (80 feet) with breaker bar equipment.

f. Time of day. When the air is relatively still (conditions of inversion or low turbulence); for example, early morning about sunrise. Consultation with the weather officer is recommended.

10. **EQUIPMENT.** *a. B-25 airplane (equipment may be made readily in the field).* (1) *Storage tanks.* One standard fixed bomb bay fuel tank is installed and connected to one standard droppable bomb bay fuel tank by the adapter tank transfer. Total capacity is 550 gallons.

(2) *Release valve.* The valve, sump assembly, which replaces the standard sump assembly is shown in figures 2 to 8. It is a spring loaded valve. The valve is controlled manually by a rod located in the radio compartment or by a cable located in the radio or navigator compartment.

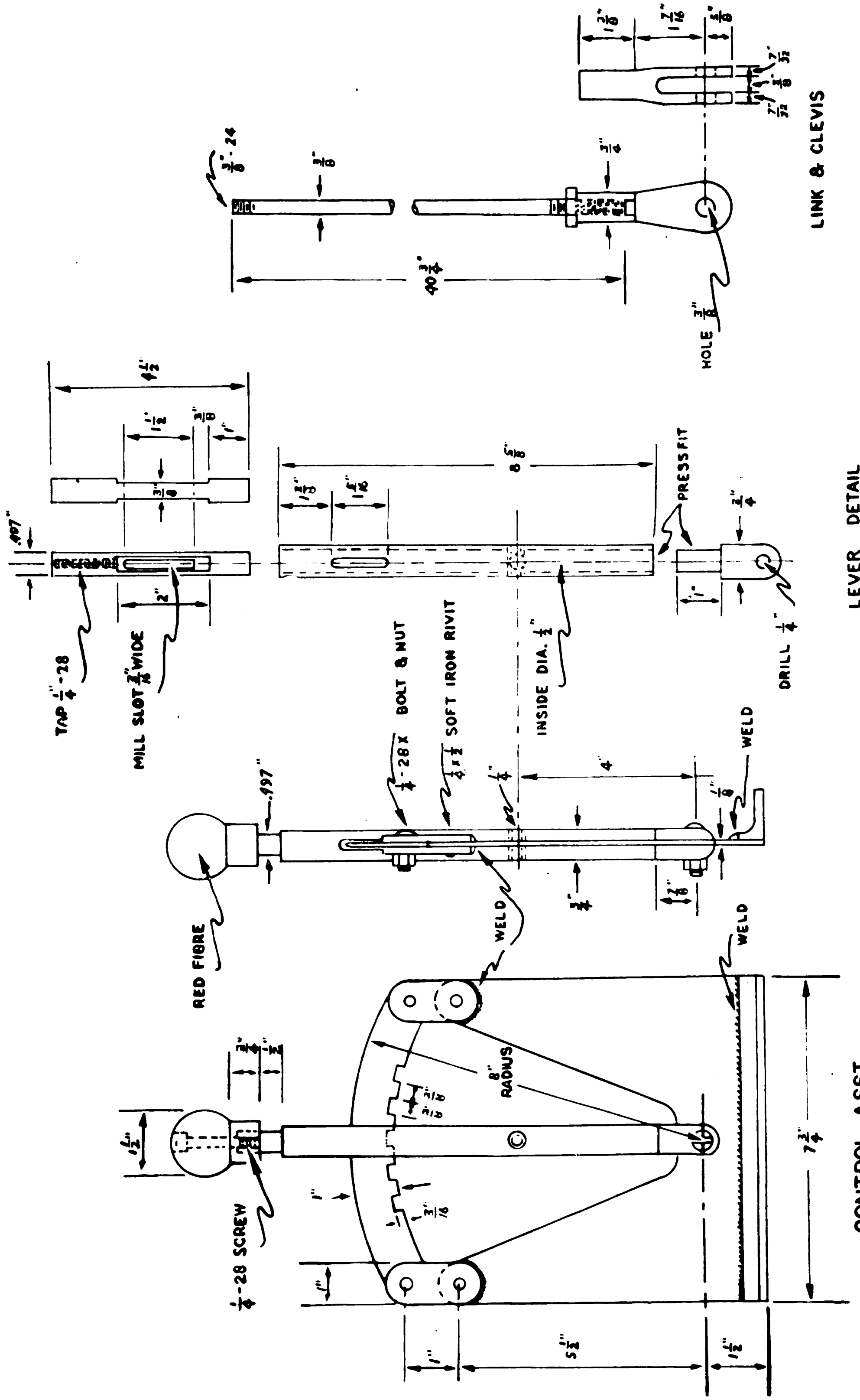

LINK & CLEVIS
HOLE
LEVER DETAIL
PRESS FIT
DRILL
TAP
MILL SLOT WIDE
INSIDE DIA.
BOLT & NUT
SOFT IRON RIVIT
WELD
RED FIBRE
WELD
WELD
RADIUS
SCREW
CONTROL ASST.

Figure 2.

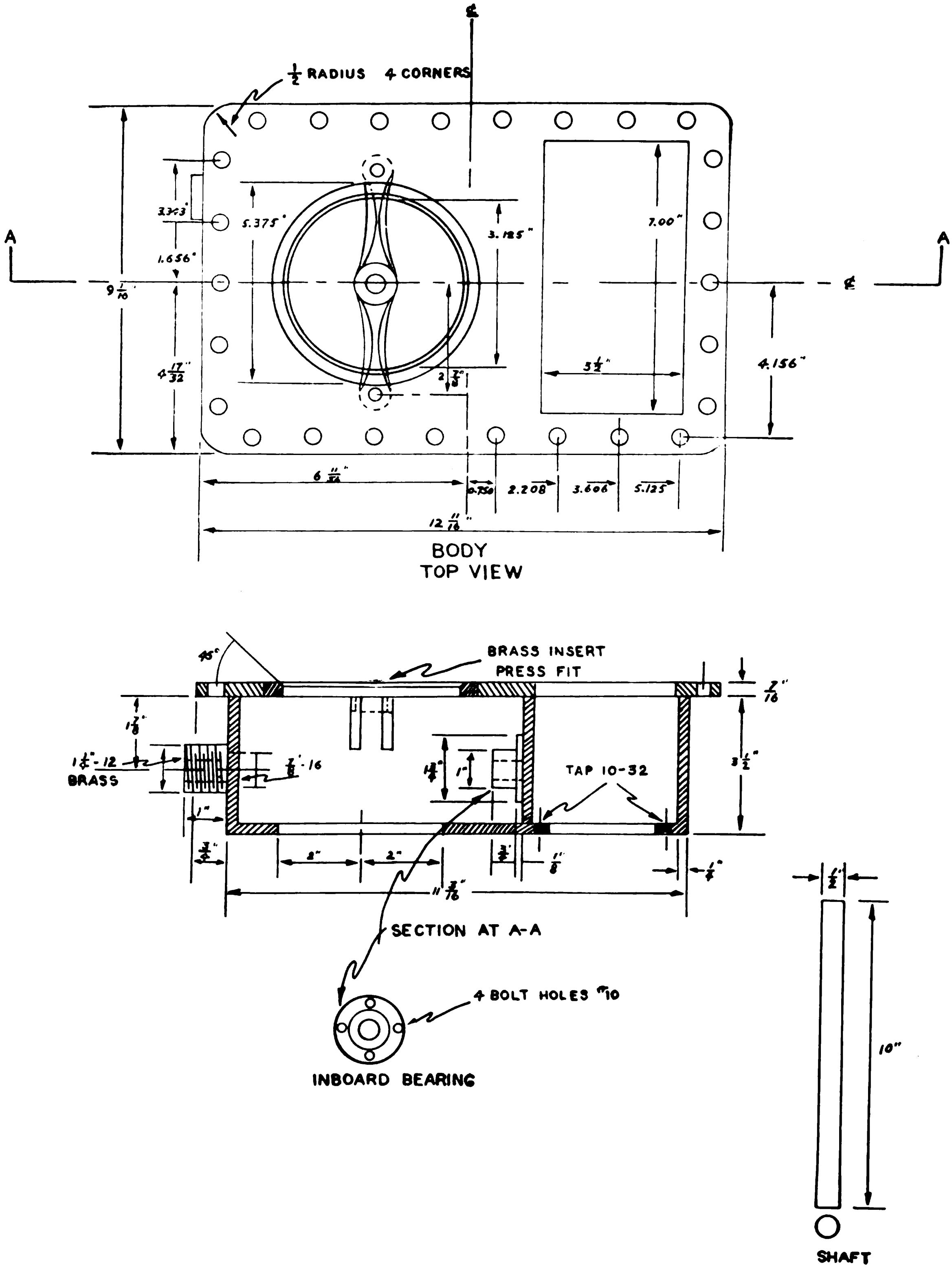
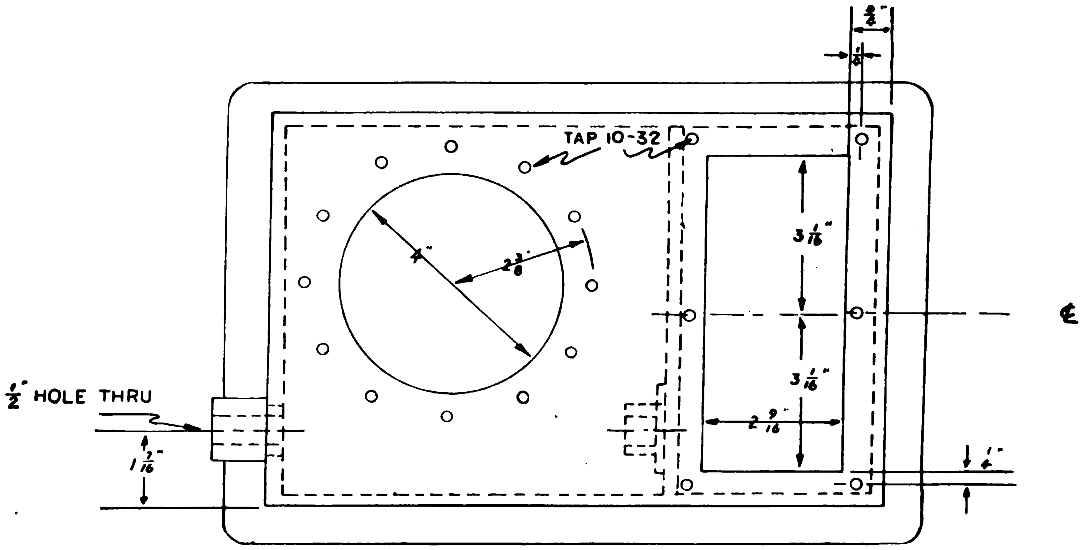
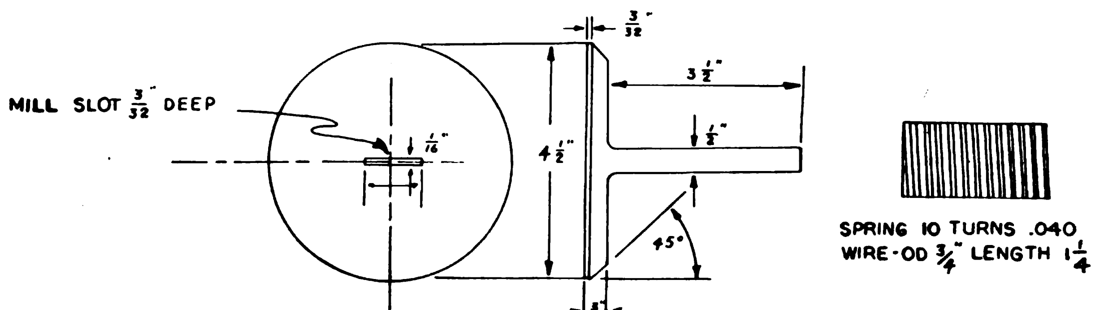

½ RADIUS 4 CORNERS
A
A
5.375"
3.125"
7.00"
1.656"
4.156"
0.750
2.208
3.606
5.125
BODY
TOP VIEW
BRASS INSERT
PRESS FIT
BRASS
TAP 10-32
SECTION AT A-A
4 BOLT HOLES #10
INBOARD BEARING
10"
SHAFT

Figure 3.



BODY
BOTTOM VIEW



POPPET

Figure 4.

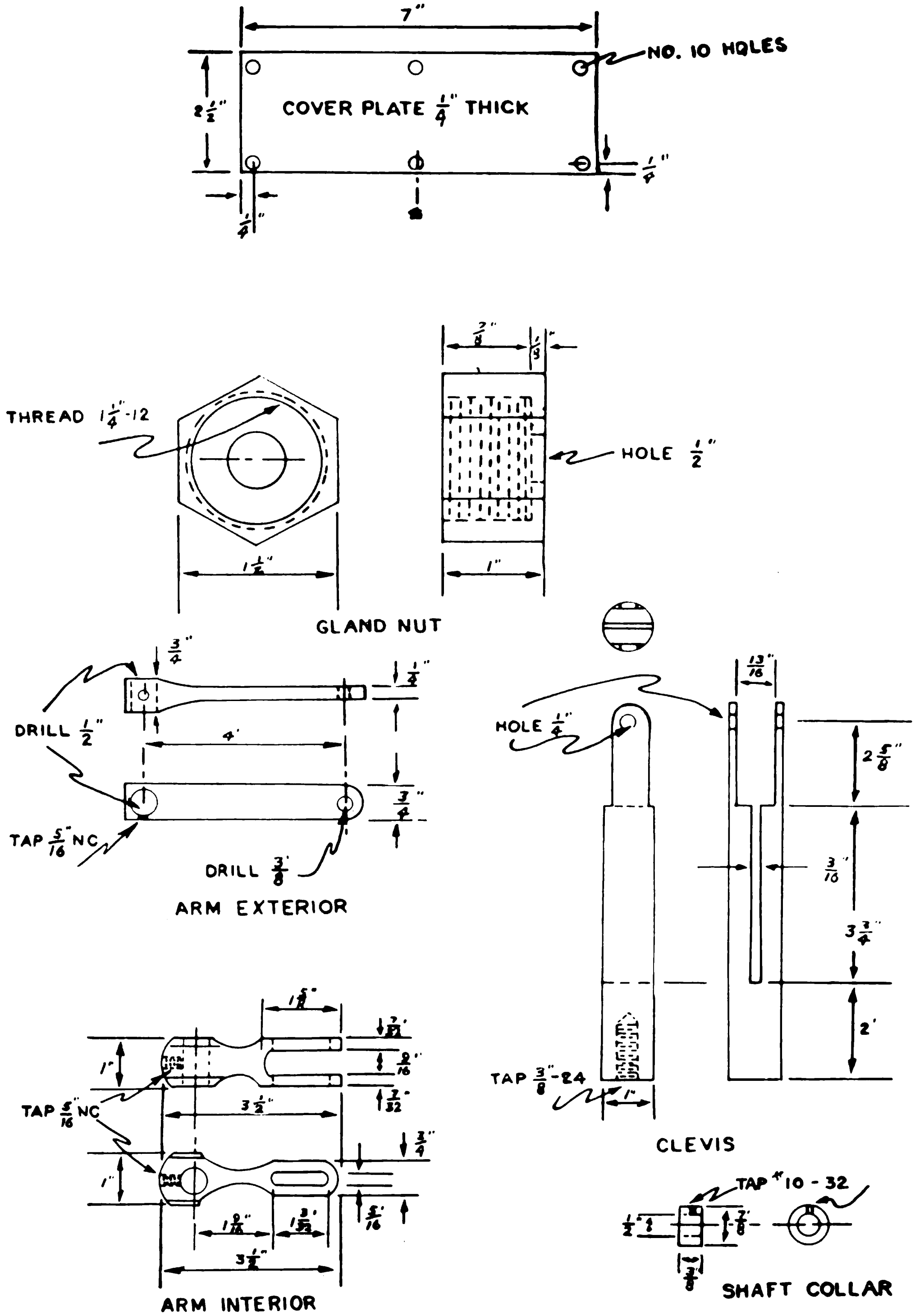

7"
NO. 10 HOLES
COVER PLATE 1/4" THICK
2 1/2"
1/4"
1/4"
THREAD 1 1/4"-12
HOLE 1/2"
1 1/2"
1"
GLAND NUT
3/4"
DRILL 1/2"
4'
3/4"
TAP 5/16" NC
DRILL 3/8
ARM EXTERIOR
HOLE 1/4"
13/16"
2 5/8"
3/16"
3 3/4"
2'
TAP 3/8"-24
1"
CLEVIS
TAP #10 - 32
SHAFT COLLAR
1"
3 1/2"
TAP 5/16" NC
3 1/2"
ARM INTERIOR

Figure 5.

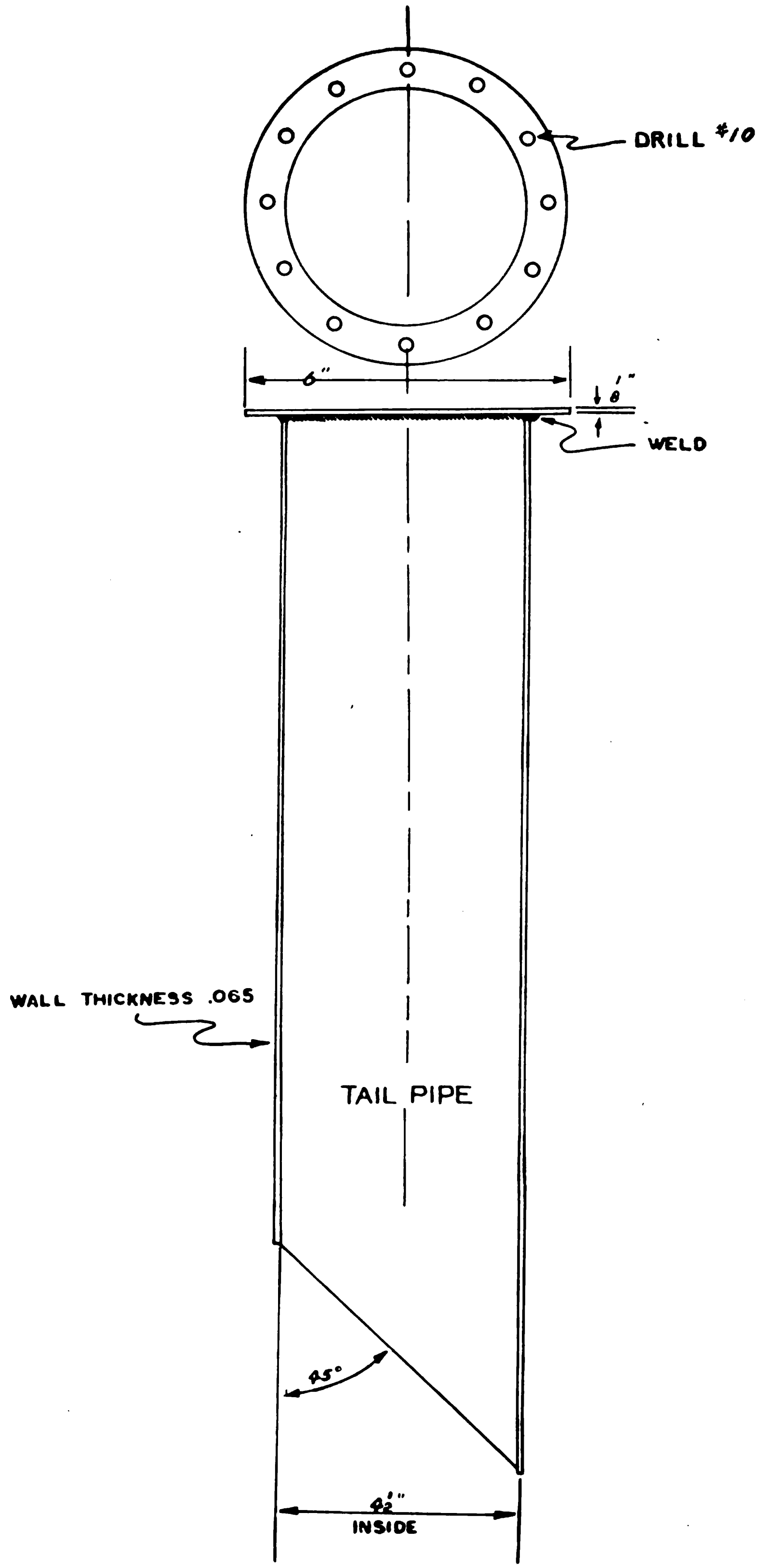


Figure 6.

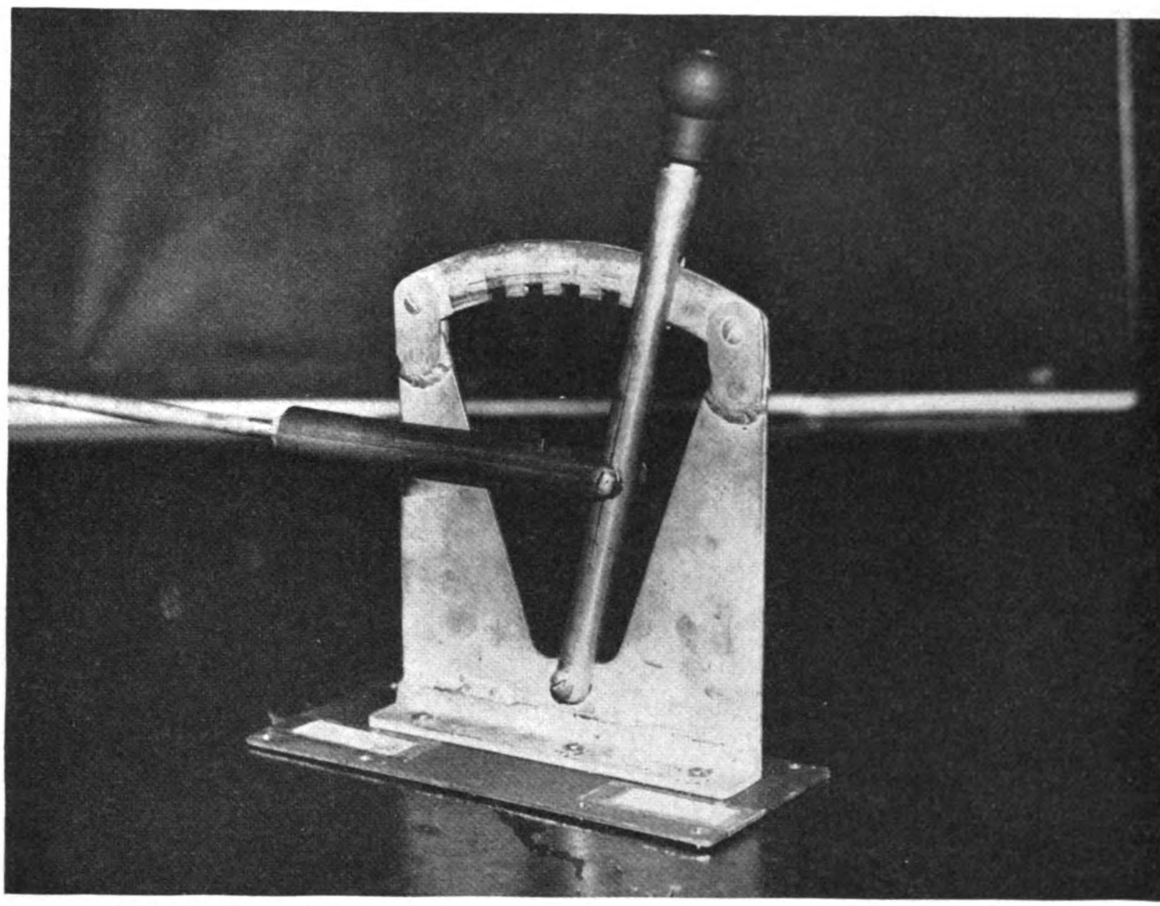


Figure 7.—Manual control for release valve. Valve-sump assembly—DDT sprayer for B–25.

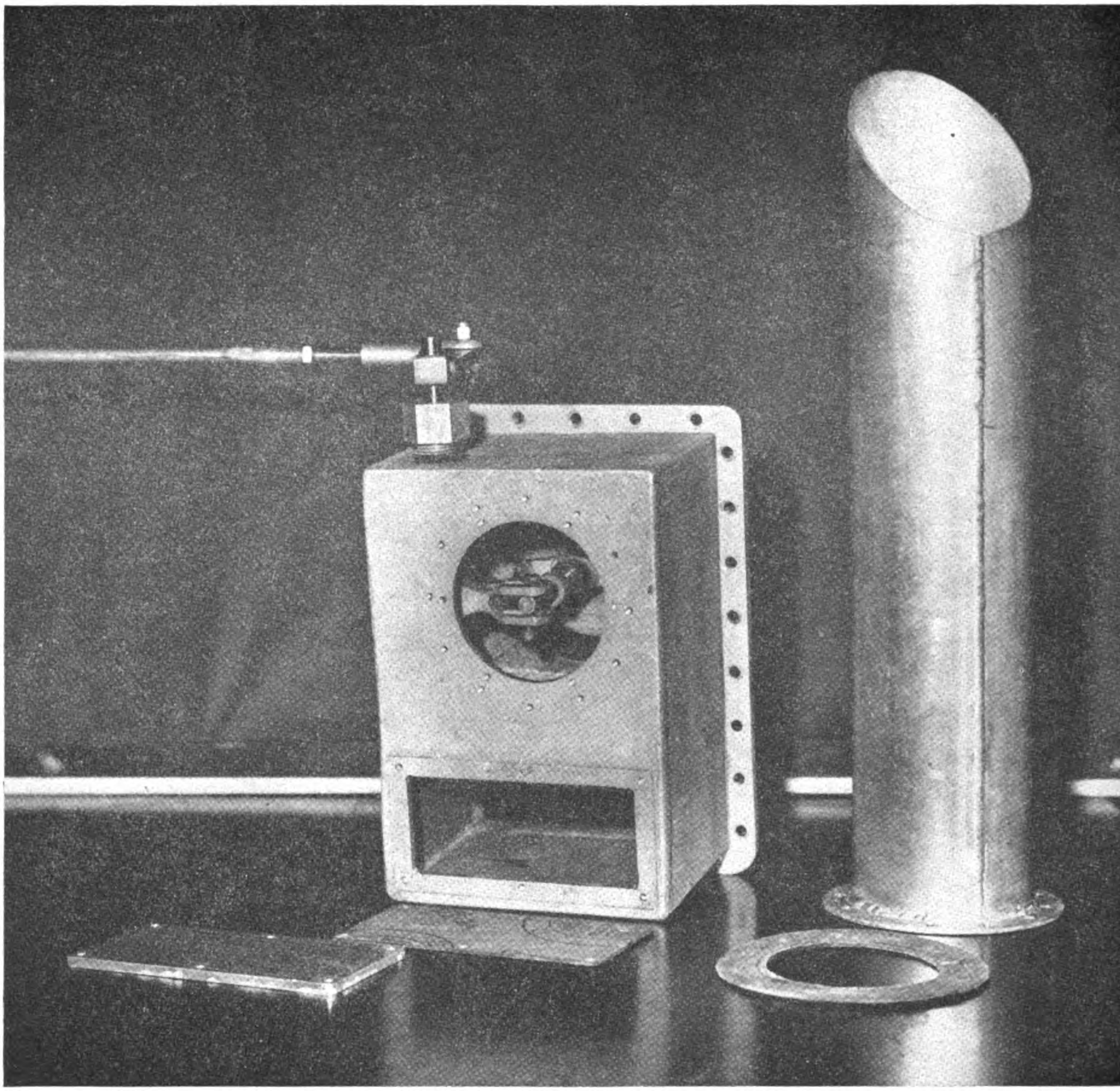


Figure 8.—Valve-sump assembly—DDT sprayer for B–25.

(3) *Dispensers.* (*a*) Straight pipe and streamlined pipe dispensers. A 4½-inch pipe is bolted to the bottom of the sump valve assembly, extending about 21 inches below the fuselage. The lower end of the pipe is cut off at a 45° angle so that the cut face points to the tail of the plane. The pipe is supported by guy wires. (See figs. 8 and 9.) For use with various concentrated solutions, a series of streamlined discharge pipes may be constructed and fitted with an outer fairing so as to permit different rates of flow.

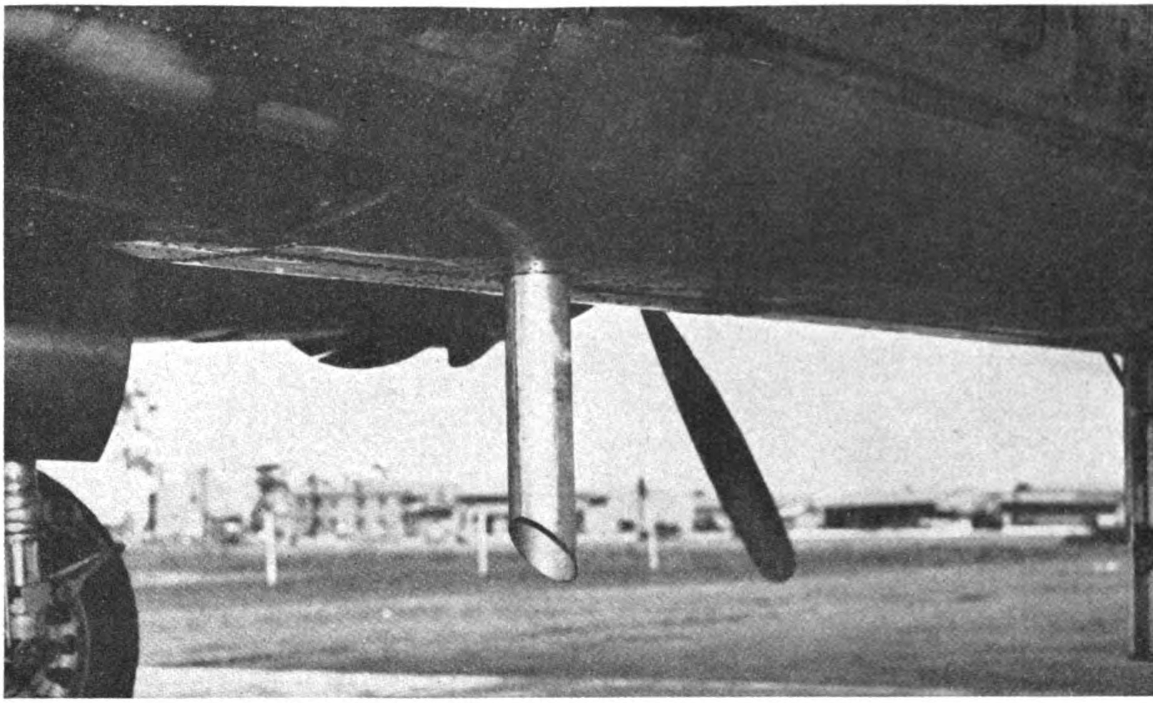


Figure 9.—Straight pipe dispenser in place on B–25 airplane.

(*b*) *Grid dispenser.* Six streamlined tubes, each 24 inches in length, are welded to the central manifold and to supporting brackets at the sides. (See fig. 10.) A series of slots are cut on the highest point of both sides, top and bottom of each streamlined tube through which the DDT solution flows perpendicularly to the air stream. The spacing of the tubes produces a venturi. The grid is connected through the central manifold by a 4½-inch pipe. The discharge rate through the grid dispenser is much more uniform and the droplet size varies less than from the straight pipe dispenser. These advantages may overbalance the simplicity of the straight pipe.

b. C–47 airplane. (1) *Storage tank.* The C–47 equipment consists of a 625-gallon tank mounted in the transport with discharge pipe equipment essentially similar to that for the B–25 plane. The equipment is currently being tested by the Army Air Forces. Drawings showing the proper installation of such apparatus will be made available through Air Technical Service Command, Wright Field, Ohio, on request.

(2) *Release valve.* A valve similar to that in the B–25 is installed in the C–47. It is operated manually by the aerial engineer or other member of the crew on signal from the pilot.

(3) *Dispensers.* See *a*(3) above.

c. L–5 airplane. (1) *Storage tank.* A tank with a total capacity of 43½ gallons (42-gal. pay load) is installed in the observer's seat.

(2) *Release mechanism.* This cannot be made in the field but may be procured through Air Technical Service Command, Wright Field, Ohio. The mechanism consists of a pump, propeller-driven, which operating at 120 pounds pressure, dispenses solution at a fairly constant rate of 10 gallons per minute. Back pressure on the pump acts as a brake on the pump propeller, when flow of solution is stopped. The con-

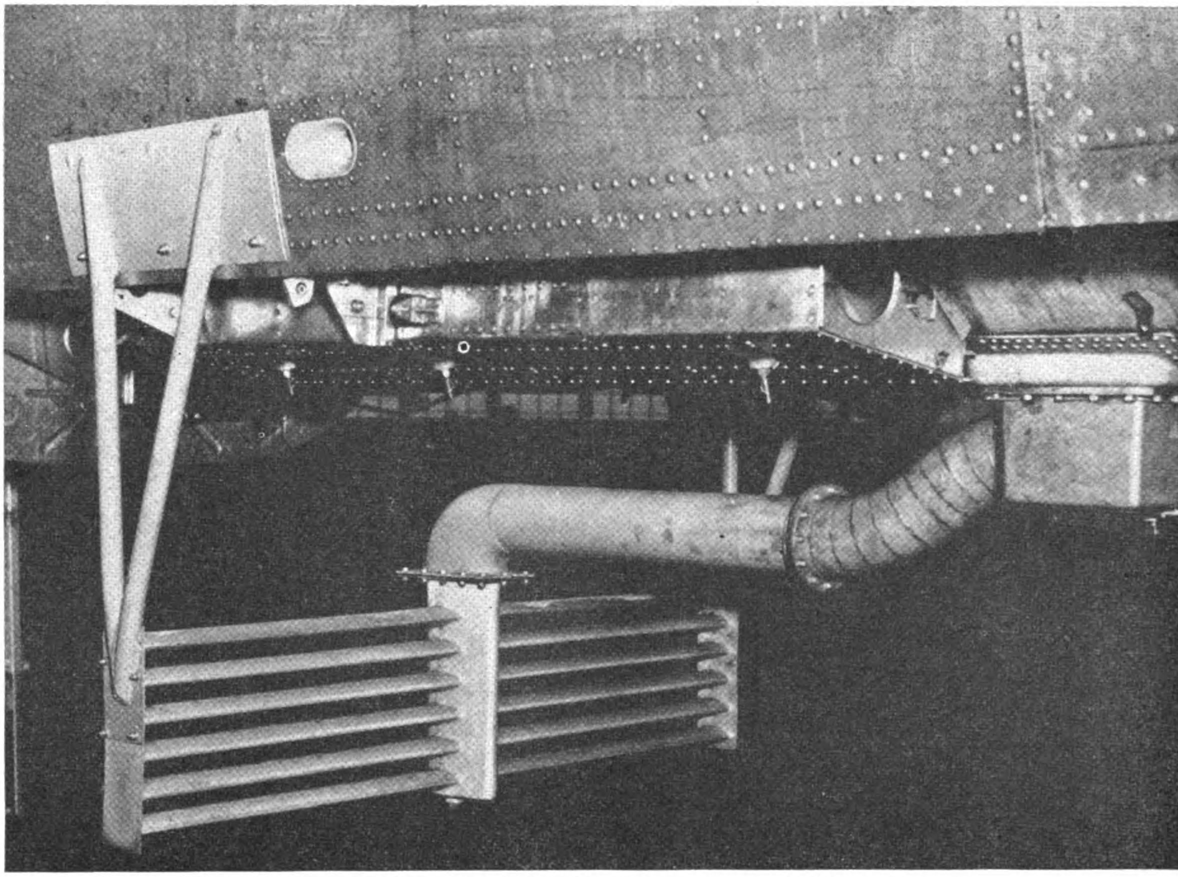


Figure 10.—Streamlined grid dispenser in place on B–25 airplane.

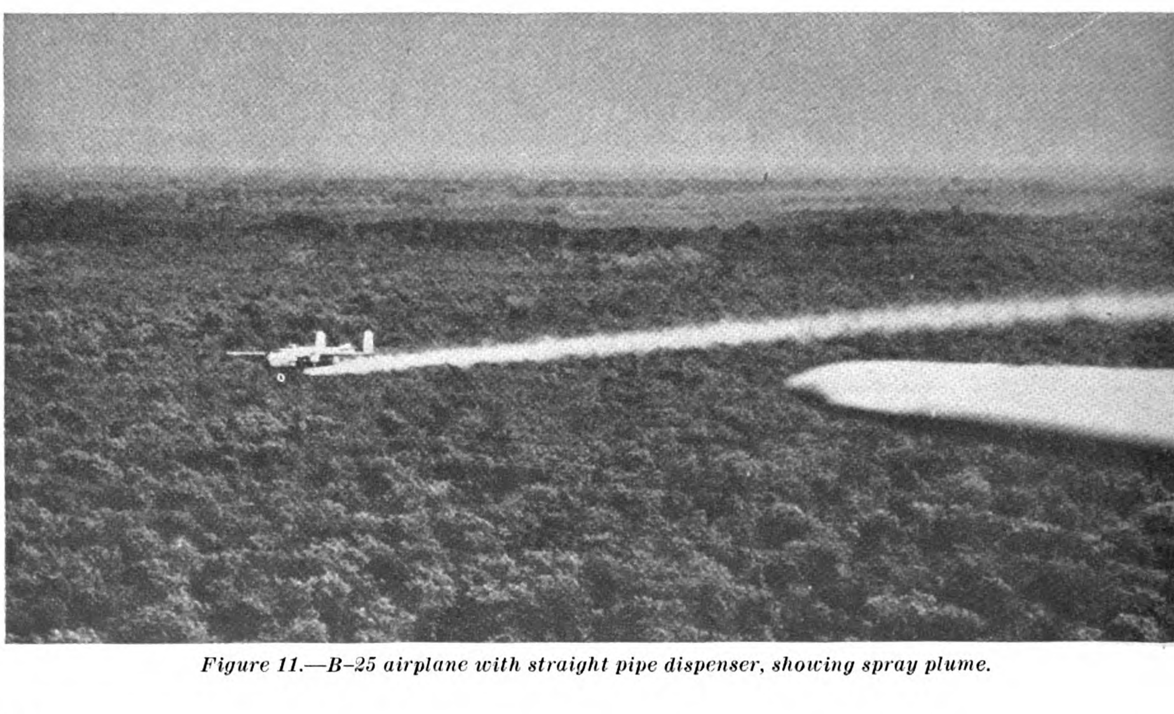


Figure 11.—B–25 airplane with straight pipe dispenser, showing spray plume.

trol is located to the left of the pilot on the fuselage. The single pump delivers solution to the two breaker bar dispensers. (See fig. 12.)

(3) *Dispenser.* One breaker bar dispenser (figs. 13 and 14) is clamped to the struts of each wing. Each dispenser is connected to the pump by flexible half-inch (I. D.) tubing. The dispenser consists of four feet of ¾-inch diameter pipe which is perforated by 40 holes of 71-wire gauge equally spaced; and a slightly beveled 5° convex milled bar clamped to the tubing ¼-inch behind the spray openings.

d. L–4 airplane. (1) *Storage tank.* A tank of 27 gallons capacity (25-gal. pay load) is installed in the observer's seat.

(2) *Release mechanism.* This is similar to that for the L–5, except that the pump propeller is set at a 44° pitch and develops 60 pounds pressure. The solution is dispensed at a fairly constant rate of 5½ gallons per minute. The pump is interchangeable with that used on the L–5, if the proper pump propeller is employed.

(3) *Dispenser.* Breaker bar is the same as for the L–5 airplane. This equipment replaces the Husman-Longcoy spray apparatus, which formerly was used on the L–4 airplane.

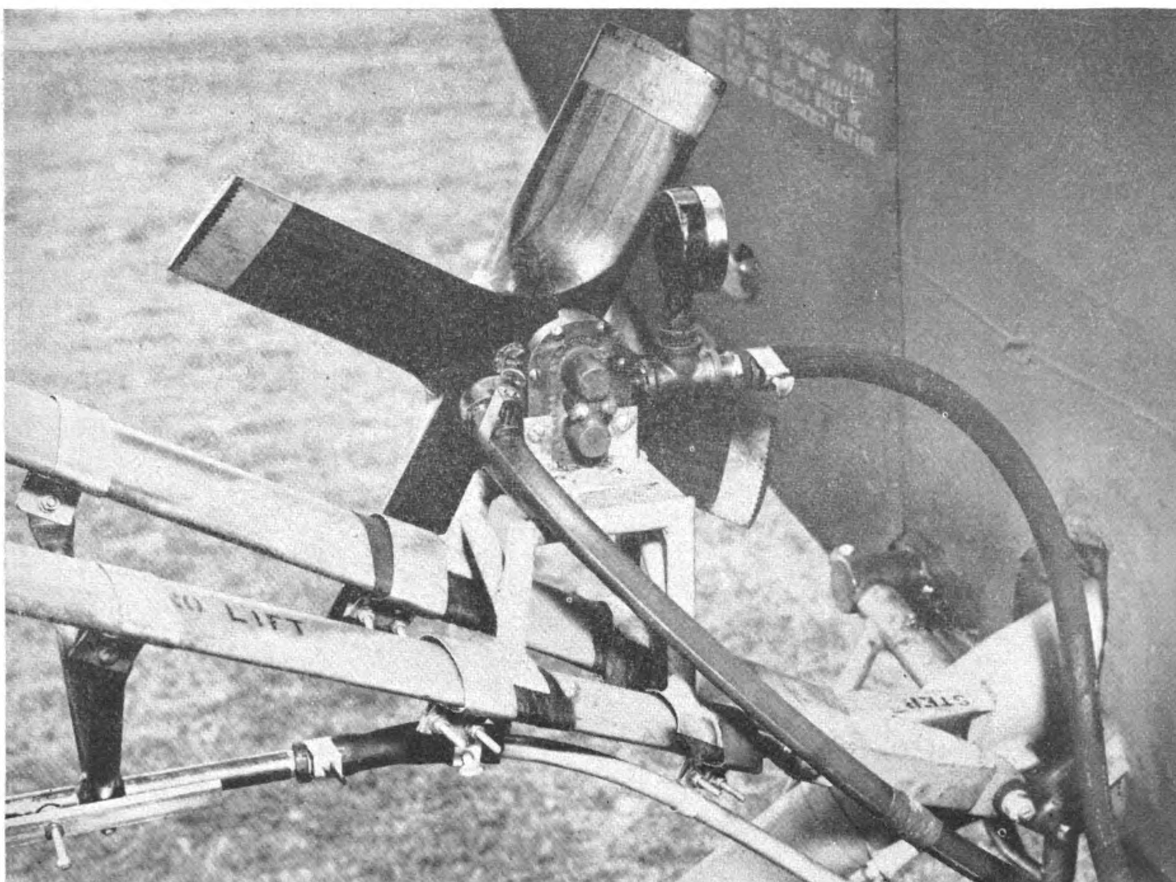


Figure 12.—Wind-driven herringbone pump. End of breaker bar shown at lower left.

Figure 13.—L–5 airplane dispensing DDT spray with breaker bar type spray equipment.

11. OPERATION OF EQUIPMENT. *a. B–25 airplane.* The apparatus is manually-controlled by a crew member, usually the aerial engineer.

b. C–47 airplane. The aerial engineer usually acts as the operator for the spray equipment on the C–47 airplane. The pilot signals the operator to start and stop the flow by use of the bail out bell, as previously arranged during the briefing of the crew. The pilot is responsible for notifying the operator in time to permit starting and stopping the flow at the correct time.

c. L–5 and L–4 airplanes. The procedures outlined below cover the breaker bar type of spray equipment.

(1) A two-positioned valve, located on the floor of the pilot's cockpit directly under the throttle quadrant, operates the flow of solution to the breaker bars. A second valve of the gate type is located slightly forward of the tank outlet. The latter must be open at all times and a maximum of 1 gallon must be left in the tank unless the pump propeller is lashed. (See par. 13*a*(2).)

(2) The pilot can start the spray by moving the breaker bar valve lever from the vertical position, CLOSED, to the horizontal position, OPEN. To stop the spray, the procedure is reversed.

(3) In order to assure the proper flow rate of the spray the pilot should make sure that the breaker bar valve is completely open, that is, moved to the full horizontal position.

12. TECHNIQUE OF SPRAYING. *a. Preparation.* (1) The flight intervals should be drawn by the pilot on a good aerial map or photograph. Recognizable landmarks and changes in elevation should be noted in relation to the flight lines. The magnetic headings can be determined from the map for use in long spraying runs.

(2) The pilot should brief the crews of the heavy type aircraft immediately prior to taking off for the spray mission. The correct size of the discharge pipe to be used should be checked and such procedures as air-ground liaison signals, signals for starting and stopping the spray, emergency signals, and the length of the run should be fully explained.

b. Flight instructions. (1) The pilot should keep in mind that the success of any spray mission is dependent on the ability to maintain exact flight intervals and altitude over any type of terrain and vegetation.

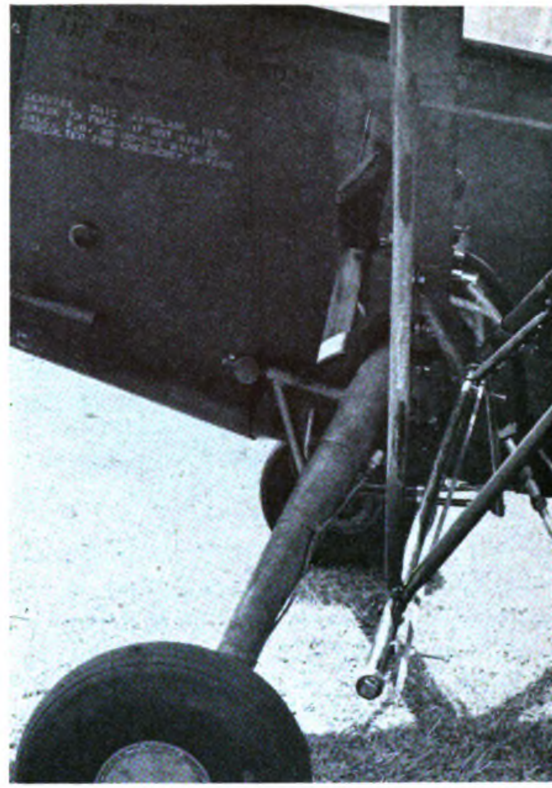


Figure 14.—Side view of spray installation showing position of breaker bar in relation to orifice area along rear surface of spray pipe.

(2) The spray runs should be made away from the sun in order to avoid early morning and late afternoon sun glare.

(3) The direction of the wind should be determined and the spray runs made as nearly to crosswind as possible. If ground observers are used, a smoke grenade may be used to show wind direction. However, the wind direction may be judged by smoke in or around the area, dust from plowing, etc., or wind disturbances on the water when no ground personnel are present.

(4) The climbing turns at the completion of the spray runs should be made to the left whenever possible in order to keep the area to be sprayed in view.

(5) The flight intervals are flown on two basic patterns as shown in the accompanying figures. The first pattern (fig. 15) is used for spray runs of 3 to 4 miles or longer in the heavy

type aircraft, and for all runs in the light airplanes. The second pattern (fig. 16) is an alternate and should be used for short runs of less than 3 miles in the heavy type airplane.

(6) The flight intervals normally should be flown 100 yards apart for the heavy planes and 27 yards (80 feet) for light airplanes equipped with the breaker bar equipment. (See fig. 17.) The entomologist may recommend varying of these intervals to satisfy certain specific conditions of terrain or vegetation.

(7) Regulation of discharge. (*a*) *Heavy types.* Open the valve 100 yards from the start of the area and close 100 yards from the end.

(*b*) *Light types.* Open the valve 30 yards from the start of the area, and close 30 yards from the end.

13. INSPECTIONS. *a. Preflight inspections.* Prior to take-off, the following checks should be made by the pilot and/or crew chief:

(1) *B–25 and C–47 airplanes.* (*a*) The synthetic rubber connections and plumbing should be checked for leakage and softening of the rubber.

(*b*) The amount of solution in the tanks should be up to the desired level.

(*c*) Prior to starting a run, the valve should be checked in flight by opening it to the smallest opening and immediately closing.

(2) *L–4 and L–5 airplanes.* (*a*) All rubber connections should be secure.

(*b*) The quantity of solution in the tank should be up to the proper level.

(*c*) The tank shut-off valve should be OPEN.

(*d*) The breaker bar valve should be CLOSED.

(*e*) When the L–4 or L–5 equipped with breaker bar are being used for continuous spraying operations, the discharge holes should be cleaned frequently.

(*f*) Operate the spray equipment while the plane is on the ground to make sure openings of the breaker bar are not blocked with grit.

(*g*) If the plane is to be flown with an empty tank, the pump propeller should be lashed down or the brake applied. This will prevent scoring and burning out the pump.

b. Seven-day inspections. Since the solutions used as solvents in aerial spraying work are deleterious to rubber connections and tanks, it is essential to check these parts at least at weekly intervals.

(1) The inner lining of the B–25 tank should be inspected for softening of the rubber around the inside of the loading vent.

(2) The valves on the C–47 and the B–25 airplanes should be checked on the ground with the tanks empty.

14. BIOLOGICAL EVALUATION OF RESULTS. *a. Control of disease vectors.* The primary military objective of DDT air spraying is the prevention of insect-borne diseases. Entomological study and evaluation should not be permitted to delay or to jeopardize attainment of this objective in the face of an epidemic or when a high rate of insect-borne disease is probable. Effectiveness of DDT in disease prevention is the result of killing the specific insect vector. A lowered disease rate will follow even if other insects are not affected. Whenever possible, a competent entomologist should be available to identify the mosquito vectors, to advise upon or direct the spraying operations, and to evaluate the results. In order to expedite the procedure, he must know what species to expect in a given area, and where and how they may be found. Much remains to be learned of the uses of DDT, and careful entomological studies in different regions under varying climatic conditions and against various types of insects are highly desirable. Grave errors regarding the effectiveness, and therefore the future applications of DDT, are likely to arise from indiscriminate aerial spraying of DDT, if accurate biological evaluation is not made, because of many factors which may distort the true picture.

b. Evaluation of results on pest insects. A secondary objective of aerial spraying is the reduction of insect pests. A sampling of individual opinion often is adequate to evaluate the results of aerial spraying against flies and pest insects. However, more exact evaluation is desirable, when personnel are available and time permits.

c. Evaluation of mosquito control. (1) *Survey prior to air spray.* (*a*) *Adult mosquitoes.*

1. By human biting or settling rates, done at the same station each day (day biters) or each evening (night

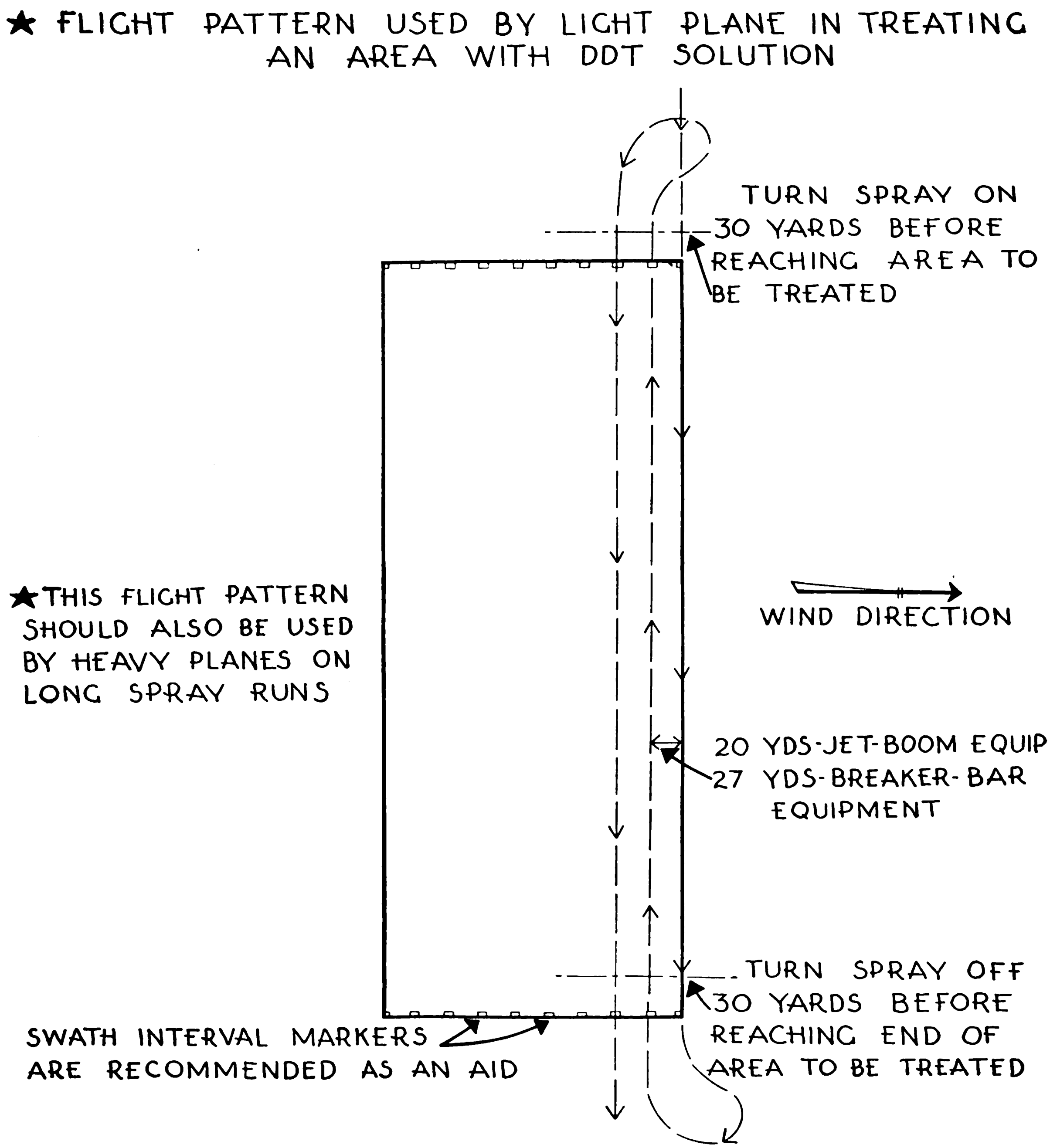

★ FLIGHT PATTERN USED BY LIGHT PLANE IN TREATING AN AREA WITH DDT SOLUTION
TURN SPRAY ON 30 YARDS BEFORE REACHING AREA TO BE TREATED
★THIS FLIGHT PATTERN SHOULD ALSO BE USED BY HEAVY PLANES ON LONG SPRAY RUNS
WIND DIRECTION
20 YDS-JET-BOOM EQUIP
27 YDS-BREAKER-BAR EQUIPMENT
TURN SPRAY OFF 30 YARDS BEFORE REACHING END OF AREA TO BE TREATED
SWATH INTERVAL MARKERS ARE RECOMMENDED AS AN AID

Figure 15.

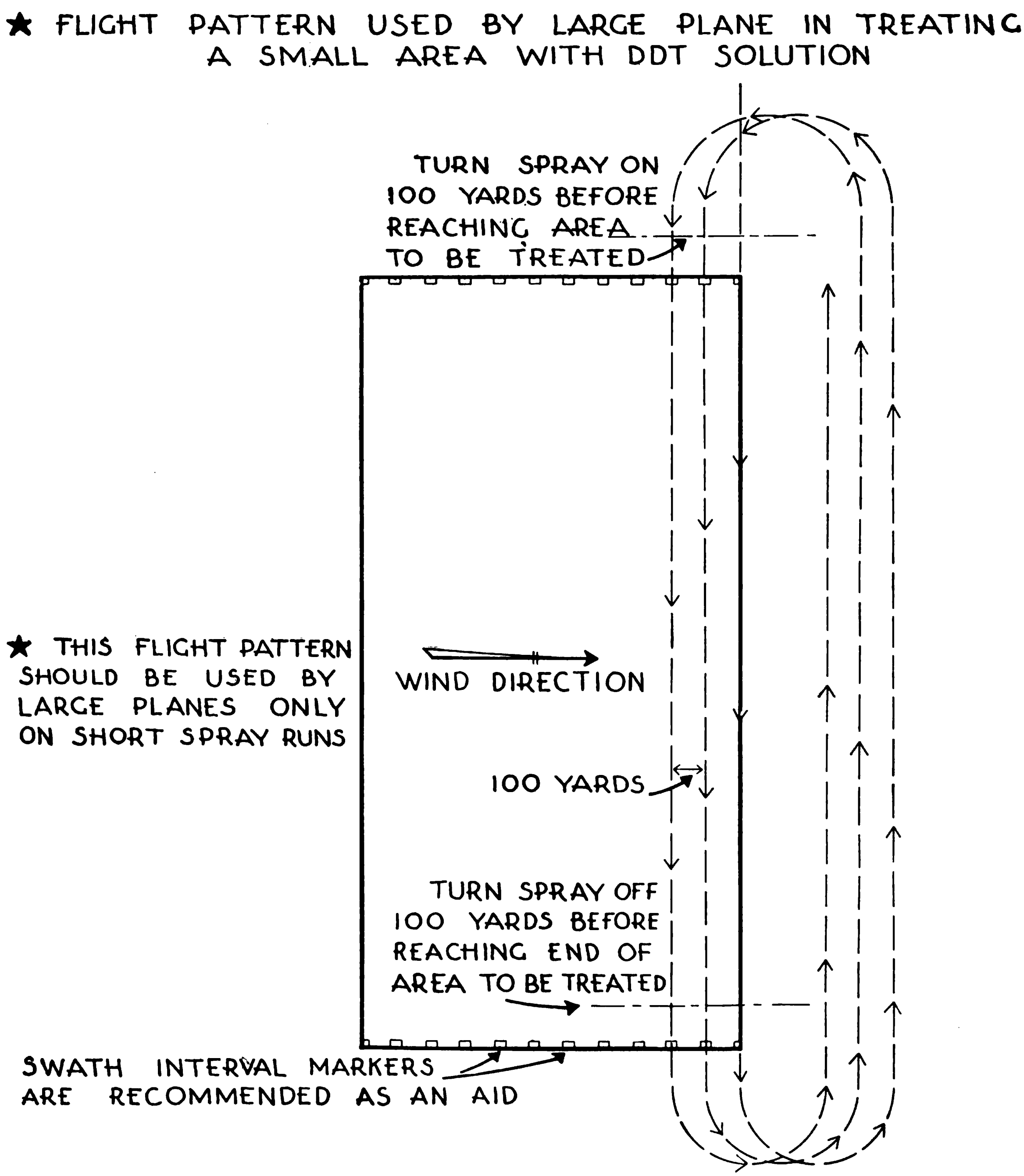

★ FLIGHT PATTERN USED BY LARGE PLANE IN TREATING A SMALL AREA WITH DDT SOLUTION
TURN SPRAY ON 100 YARDS BEFORE REACHING AREA TO BE TREATED
★ THIS FLIGHT PATTERN SHOULD BE USED BY LARGE PLANES ONLY ON SHORT SPRAY RUNS
WIND DIRECTION
100 YARDS
TURN SPRAY OFF 100 YARDS BEFORE REACHING END OF AREA TO BE TREATED
SWATH INTERVAL MARKERS ARE RECOMMENDED AS AN AID

Figure 16.

SCHEMATIC DIAGRAM SHOWING SPRAY DISTRIBUTION WITH CONSTANT FLIGHT INTERVAL AND OPTIMUM CONDITIONS

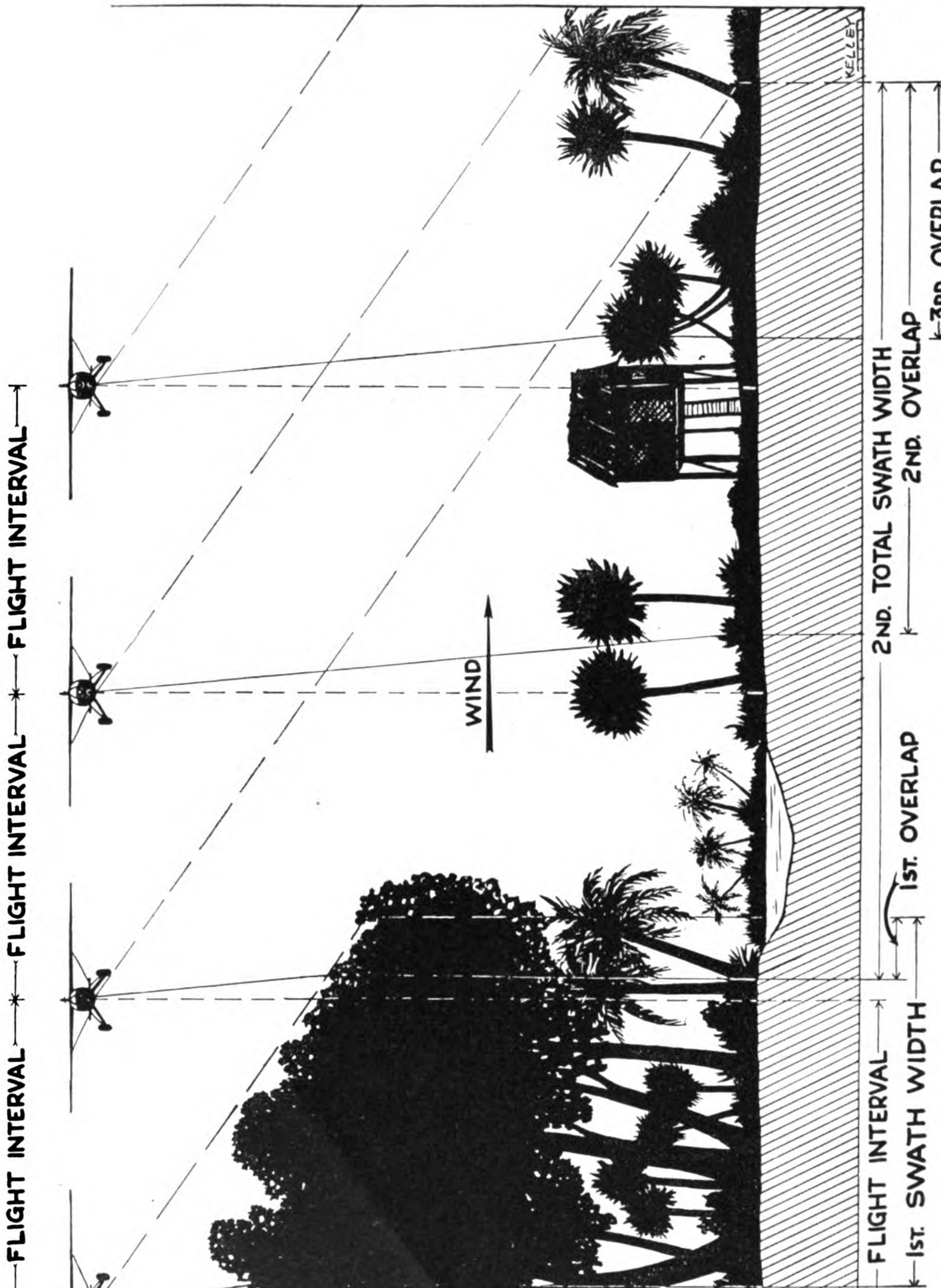


Figure 17.

biters). Where rates are 10 or less per man per 2 minutes, a survey should be made daily for 7 days, if practicable, to obtain adequate figures. Stations may be established 300 yards apart along a blazed trail or in some other pattern. Having stood still for 5 minutes after arrival at a station, one of two men should act as "bait" for a 2-minute period counting the mosquitoes which alight on the front portion of his body, while the other man counts those which alight on the first man's back. The two counts are totaled and recorded. This process is repeated at each station. Probably a more reliable check is made by the two men collecting biting mosquitoes in chloroform tubes. Although this method is somewhat more painful, particularly where mosquitoes are very abundant, it provides the advantage of retention of the specimens for identification. (They can be kept in numbered pill boxes.) Where the biting mosquitoes are disease vectors, a risk of infection will be entailed in this method of evaluation.

2. By counting mosquitoes in their daytime resting places. They should be killed before counting. It is important to count the disease vectors.

3. By species identification. The entomological objective is reduction of disease vectors, in most instances; and so long as the population of such mosquitoes is controlled, the primary objective will be attained.

4. By extending the survey of the mosquito density in a zone not exceeding the flight range of the specific vector around the area to be sprayed.

(*b*) *Mosquito larvae.* Dipping counts from a uniform surface of water (e. g., 1 square foot) should be made from appropriate locations, with identification of the species.

(2) *Post-spray surveys.* (*a*) Counts of adult mosquitoes should be made 4 hours, 24 hours, and at weekly intervals after spraying. Respraying is indicated when the population of disease vectors increases. The same personnel and same method should be used at the same prespraying and postspraying stations because individuals vary in attractiveness to mosquitoes and in their ability and method of counting.

(*b*) Larval counts, using the same technique as before spraying, should be made after 24 hours and at weekly intervals.

(*c*) Results are expressed as percent reduction.

d. Reports. It is desirable that reports contain information on the following subjects:

(1) *General.* (*a*) Location of area and dimensions (draw on aerial map or photograph).

(*b*) Dates of study.

(*c*) Time of spray.

(2) *Vegetation.* (*a*) Woody plants.

1. Species predominant.

2. Average percent cover—low, 0 to 33 percent; medium, 33 to 66 percent; high, 66 to 100 percent.

(*b*) Herbaceous plants (as above).

(3) *Buildings in area.* Types and concentrations. Incidence of insect-borne disease in the occupants.

(4) *Meteorology.* (*a*) Air temperature.

(*b*) Water surface temperature.

(*c*) Condition of thermal stratification (behavior of smoke), inversion or lapse.

(*d*) Wind velocity (on ground) and direction.

(*e*) Rainfall.

(5) *Treatment data.* (*a*) Formula used.

(*b*) Type of aircraft and equipment.

(*c*) Rate of application.

1. Discharge rate in gallons per minute.

2. Indicated air speed.

3. Flight interval.

4. Altitude above the ground and treetops.

(6) *Mosquito population data.* (*a*) Principal species of adults.

1. Mean biting rate per man per minute.

2. Average number per resting station.

(*b*) Principal larval species. Mean number per square foot in breeding areas.

(*c*) Percent control of adults and of larvae.

Appendix

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